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APPARATUS AND METHOD FOR EXCHANGING VEHICULAR FLUIDS

FIELD OF THE INVENTION

[0001] The present invention relates to an apparatus and method for exchanging vehicular fluids, and more specifically to an apparatus and method for exchanging vehicular fluids according to fluid volume.

BACKGROUND OF THE INVENTION

[0002] A vehicular transmission system transfers engine power to the vehicle drive train, allowing the engine to operate in a narrow speed range, while providing a wide range of output speeds and torques to the drive train. This power transfer is accomplished within the transmission, in which a plurality of gears automatically select the proper gear ratio, in conjunction with the position of the user operated transmission gear shift, based on the vehicle's speed and torque demand.

[0003] Two other components associated with the transmission system include the torque converter and the gear or fluid pump. The converter is mounted to the engine flywheel (which is in turn mounted on the engine drive shaft) to provide fluid coupling between the engine and the transmission, allowing the engine to spin somewhat independently of the transmission. Thus if the vehicle is idling in a stopped condition, the amount of torque transferred by the torque converter is small so restraining vehicular motion requires only slight brake pressure. At higher engine speeds, more fluid is pumped into the torque converter by the fluid pump, causing more torque to be transferred from the engine to the transmission and to the wheels.

[0004] The pump, typically affixed to the transmission cover, draws fluid from a sump in the bottom of the transmission cover or pan and feeds the fluid to the hydraulic system (for controlling and actuating the transmission gear ratios), the torque converter and the transmission fluid cooler. The transmission fluid cooler, a cooling device within the radiator but separate from the main engine cooling, comprises a heat exchanger where the fluid releases heat energy to the cooler radiator coolant.

[0005] In the automatic transmission system described above the transmission fluid is stored, delivered, and transferred through various rigid enclosed passages, chambers,

orifices, mechanisms, or pumping/metering devices, all of which require regular cleaning to ensure proper service and system life to remove fluid contaminants and or by-products of the automatic power transmission process that can foul and cause premature wear to system components or otherwise impair system performance.

[0006] If contaminants, such as dirt, oil sludge, gum, varnish, burned oil, deposits from worn parts, residues of transmission fluid additives, etc., are not properly flushed from the automatic transmission system, they can cause slow and hesitant acceleration, rough or erratic shifting, incorrect shift points, excessive creep and abnormal vibration when gears are shifted, gear position slippage or lock up, premature transmission fluid burn-out causing excessive fluid consumption and overheating, premature component wear. If these problems are not resolved in a timely manner, an expensive transmission overhaul may be required.

[0007] The simplest method for changing automatic transmission fluid involves dropping or removing an automatic transmission pan to allow the transmission fluid to drain (or draining the pan for those transmissions equipped with a drain plug), followed by refilling the transmission to the proper level with new fluid. It is known, however, that when employing this method more than half of the used and contaminated transmission fluid remains in the transmission and the various related components operative therewith, including the clutch actuators, control valves, pump(s), transmission fluid cooler and connecting conduits, and the torque converter.

[0008] Alternatively, the fluid can be withdrawn through a suction tube inserted through a transmission fluid dipstick tube. Like the drain and fill process, the suction tube process also results in the retention of considerable used fluid within the transmission system. Clearly, these processes merely dilute the used fluid with new fluid while a proportion of the various contaminants remain within the system.

[0009] To improve the fluid replacement process, there are known machines for withdrawing the used fluid transmission fluid while adding fresh or new fluid to replace the used fluid. To effectively extract the used fluid from the transmission system components, the vehicle engine is operated to allow the transmission fluid system pressure to evacuate substantially all of the used fluid from the various components. Operation of the vehicle engine activates the transmission fluid pump, creating the transmission fluid pressure that causes transmission fluid flow through the torque converter and other transmission components to flush the used fluid from the

transmission system. According to these known machines, the transmission system pressure also powers the machine components that infuse the new fluid into the vehicle's transmission system.

[0010] Advantageously, during the fluid exchange process the vehicle is mounted on a chassis roller set to permit operation of the drive wheels and cycling of the transmission through its various gear ratios. Alternatively, the vehicle engine can be run with the transmission in "neutral" or "park." The latter process is less efficient than the former with respect to the quantity of used fluid replaced with new fluid.

[0011] Most prior art fluid exchange (or flush) machines perform the fluid exchange by connecting into the transmission fluid cooling flow path at a location where the fluid enters or exits the radiator (or other cooling component) referred to generally as the cooler lines or coolant lines. These machines utilize the pressure/flow of the used fluid in the cooler line to operate functional components of the flush machine and perform the fluid exchange. Such machines use pistons, bellows, gear drives, etc. that are somehow displaced, moved, or turned by the incoming used fluid from the vehicle. For example, one such machine comprises a floating piston in a cylinder. The cylinder area above the piston is filled within new fluid and the pressurized used fluid is introduced into the bottom to the cylinder from the cooler line. As the used fluid applies pressure to the underside of the piston, the piston is driven upwardly to force the new fluid into the transmission system. In another prior art technique, a flexible bladder replaces the piston.

[0012] It is known that the time required to perform a transmission fluid exchange is directly related to the speed at which the vehicle can pump used fluid through the cooler line. Use of the force/pressure of the vehicle's used fluid to infuse new fluid into the transmission system can result in a slow exchange process, as the exchange duration depends on the pressure of the used fluid as it exits the vehicle and the mechanism by which the pressurized fluid flow operates the flush mechanism. This pressure can range from 5 psi (pounds per square inch) to 50 psi depending on vehicle make and model. Thus the prior art techniques require a fluid exchange machine that can accommodate all expected vehicle pressures.

[0013] In an effort to accelerate the flush and exchange processes for low pressure vehicles, it is known to use booster pumps or mechanically assisted components to supplement the energy derived from the fluid flow. Many vehicles, such as Toyota

automobiles and various Ford products, operate on a low flow/pressure transmission system. The typical operating pressure is under 10 psi and can be as low as 6 or 7 psi. A prior art gear-driven flush machine requires almost 5 psi to operate the gear-drive mechanism, leaving little pressure to accomplish the fluid exchange. Thus when employing such a machine with a low-pressure vehicle, the fluid exchange process may require 30 to 40 minutes. In addition to the extended customer wait time, it is known that a longer duration exchange allows more intermixing of the new and used fluids within the transmission system, thus reducing the amount of fluid actually exchanged. A faster exchange of used fluid for new fluid is preferred to limit the intermixing.

[0014] In contrast to the low-pressure designs above, certain late model vehicles are designed with high-pressure fluid transmission systems. These pressures may be excessive for certain existing fluid flow machines, and can damage machine components. Additionally, the prior art machines may not be able to supply a sufficiently high pressure to the new fluid as it is infused into the vehicle.

[0015] Another disadvantage encountered in the prior art fluid exchange machines is caused by the expected viscosity differential between the new and the used fluids during the exchange process. The viscosity of the old fluid is lower than the viscosity of the new fluid (i.e., the new fluid is thicker). Machine inefficiencies will arise as the incoming lower viscosity used fluid attempts to force the higher viscosity new fluid into the vehicle, as the pressure supplied by the old fluid to force the new fluid into the vehicle may not be sufficient given the higher viscosity of the new fluid.

[0016] Several different fluid exchange machines are known in the art. One such flushing machine for an automotive automatic transmission is known according to U.S. Patent Number 5,337,708, issued 16 Aug. 1994 to We-Yu Chen. This patent is believed to teach a transmission fluid exchange machine in which the transmission fluid circulation loop is opened to serially connect the flushing machine into the loop. In one mode of operation the used transmission fluid, possibly including a transmission flushing solution, is circulated through the machine for receiving old transmission fluid and supplying fresh fluid to the transmission system at a selected pressure or volume delivery rate. The Chen machine operates from the vehicle's twelve-volt power supply for powering a pump to move new transmission fluid from the fluid tank to the vehicle's transmission. The operator visually inspects the fluid color as the fluid travels through a sight tube, terminating the process when the color indicates the presence of new fluid.

[0017] Another transmission fluid change apparatus is disclosed by U.S. Pat. No. 5,318,080, issued 7 Jun. 1994 to James P. Viken. The '080 patent is believed to disclose an apparatus in which supply of the new transmission fluid is provided from a pressurized storage container, which container is pressurized by the inflow of used fluid pumped from the transmission by its gear or fluid pump. The storage container has a chamber that is separated by a flexible wall (i.e., a rolling-diaphragm piston) into two sub-chambers that expand and contract in opposition. As one sub-chamber receives used fluid, new fluid is displaced from the other sub-chamber into the transmission. Another embodiment of this device uses two separate containers, one receiving the old fluid and the other holding new fluid. Air displaced from the one container as the old fluid enters is routed into the other container to drive the new fluid into the transmission. A pressurized air assist for the new fluid delivery is provided. There is considerable uncertainty with these prior art machines that the rate of new fluid delivery substantially matches the rate of old fluid drainage from the transmission under service, possibly creating a situation where the transmission may be operating with insufficient fluid and damaging the system.

BRIEF SUMMARY OF THE INVENTION

[0018] A fluid exchange process according to the present invention withdraws a used fluid from a system and supplies a new fluid into the system. The process comprises withdrawing the used fluid from the system into a first chamber and supplying the new fluid into the system in response to the used fluid in the first chamber, and removing the used fluid from the first chamber.

[0019] The present invention further comprises a machine for exchanging a used fluid in a system with a new fluid. The machine comprises a first fluid flow path for receiving the used fluid from the system and a second fluid flow path for infusing the new fluid into the system. A first pump is responsive to the volume of the used fluid received from the system for supplying a substantially equivalent volume of the new fluid into the system through the second fluid flow path.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The features of the fluid replacement machine and a method for replacing fluid constructed according to the teachings of the present invention will be apparent from the

following more particular description of the invention, as illustrated in the accompanying drawings, in which like reference characters refer to the same parts throughout the different figures. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

[0021] Figure 1 illustrates a schematic of a fluid exchange machine according to the teachings of the present invention; and

[0022] Figure 2 illustrates a four-way valve suitable for use with the fluid exchange machine of Figure 1. Figure 3 illustrates the fluid exchange machine of Figure 1 connected to a vehicle.

DETAILED DESCRIPTION OF THE INVENTION

[0023[Before describing in detail the particular fluid replacement machine and a method for replacing fluid according to the teachings of the present invention, it should be observed that the present invention resides primarily in a novel and non-obvious combination of elements and method steps. Accordingly, the elements have been represented by conventional elements in the drawings, showing only those specific details that are pertinent to the present invention, so as not to obscure the disclosure with structural details that will be readily apparent to those skilled in the art having the benefit of the description herein.

[0024] One advantage of a machine and process according to the teachings of the present invention is use of the volume of used fluid evacuated from the system to control the exchange process. The use of pressure/force of the used fluid from the vehicle, as disclosed by the prior art, is not employed. As stated above, the exchange time is dictated by the speed at which a vehicle can pump or push its fluid from the transmission system. According to the present invention, the exchange machine provides the pumping action to infuse the new fluid, based on the volume of old fluid that is pumped from the vehicle. The inventors have found that the fluid exchange time for the machine of the present invention is in most cases twice as fast as the typical prior art machines.

[0025] Figure 1 is a fluid circuit schematic for a fluid exchange machine 10 constructed according to the teachings of the present invention. The process of the present invention begins by inserting the fluid exchange machine 10 in series with the transmission fluid cooling path. As described above, the transmission system includes a

fluid line to a heat exchanger, such as the vehicle radiator, where the fluid is cooled by heat transfer to the cooler cooling fluid, then returned to the transmission system via a cooling return line. Thus the two connections between the fluid lines and the radiator (one connection serving as a fluid input to the radiator and the other serving as a fluid output or return line from the radiator) present easily accessible junctions for connecting the fluid exchange machine 10 into the transmission system. Typically, the radiator output (cooler) connection is accessible near an upper end of the radiator and is thus an easier connection junction for the machine 10. To effect the connection, the return line carrying fluid from the radiator (or more generally, the heat exchanger) to the transmission is disconnected from the radiator. A mating adapter 12 connected to a fluid line 13 is attached to the radiator (not shown) or to the fluid return line (not shown). A mating adapter 14 connected to a fluid line 15 is attached to the other connection. The machine 10 is now serially connected into the transmission fluid cooling path.

[0026] In a preferred embodiment electrical power to operate the machine 10 is supplied from the vehicle's battery, thus permitting the fluid exchange operation in an area where a fixed power source is not available. In another embodiment an external power source is used, which may comprise suitable voltage conditioning components to produce electrical current compatible with the components of the machine 10. The process thus continues by connecting machine power cables (not shown) to the vehicular battery to power the machine 10.

[0027] At this point in the process, the machine main switch (not shown) is in an OFF or closed loop mode position. Both manually operated directional valves 18 and 20 are pointing in the same direction, i.e., both to an A position or both to a B position. Arrowheads within the valve body illustrated in Figure 1 indicate the fluid flow direction through the valve when the valve is in the associated position, i.e., the A or the B position. The vehicle is started and the fluid level and fluid condition are determined by inspection of fluid residue on the dipstick.

[0028] The pressure created by the vehicle's transmission fluid pump causes fluid to circulate into the machine 10 via one of the mating adapters 12 and 14, and to return to the transmission via the other one of the mating adapters 12 and 14. A machine operator checks the flow indicator 22, including a ball 23, to determine the direction of fluid flow. A correct direction is indicated when the ball 23 is forced in the direction of an arrowhead depicted within the flow indicator 22 in Figure 1. If the flow direction is

incorrect the operator turns both directional valves 18 and 20 to the alternative position. That is, if the valves 18 and 20 were in the A position the operator moves both to the B position and vice versa. By employing two valves in the machine 10, the operator can easily remedy the problem of incorrect fluid flow direction without having to disconnect and reverse the connections of the mating adapters 12 and 14.

[0029] If the mating adapter 12 is connected to the radiator and the mating adapter 14 is connected to the cooling return line, while the vehicle is running the hot used fluid enters the machine 10 from the radiator through the mating adapter 12, the fluid line 13 and the B position of the valve 18. The used fluid flows through a tee junction 26, the flow indicator 22, a heat coil 30, a pressure gauge 32, a normally-opened path of a solenoid 36 (where the normally-opened path is indicated by a solid arrowhead and an energized path is indicated by a dashed arrowhead within the body of the solenoid as depicted in Figure 1). The fluid passes through a fluid line 38 and a tee junction 40, returning to the vehicle's return line through the valve 20 (in the B position), the fluid line 15 and the mating adapter 14. Note that with the valve 20 in the B position, fluid flow from tee junction 26 into the valve 20 is prevented. Also, a check valve 41 prevents flow into a fluid line 42.

[0030] Alternatively, if the mating adapter 12 is connected to the cooling return line and the mating adapter 14 is connected to the radiator, the fluid path is altered. The used fluid enters the machine 10 from the radiator through the mating adapter 14, the fluid line 15 and the A position of the valve 20. The fluid then flows through the tee junction 26 and the flow indicator 22, continuing through the same components in the same direction as set forth above. The fluid returns to the vehicle's cooling return line through the A position of the valve 18, the fluid line 13 and the mating adapter 12. Note that with the valve 18 in the A position, fluid flow from tee junction 26 into the valve 18 is prevented.

[0031] Once the correct flow direction is established and confirmed, the operator can check the transmission system fluid pressure with the pressure gauge 32 and visually inspect the fluid color and quality through a sight glass (not shown in Figure 1). In one embodiment, the flow indicator 22 also performs the sight glass function. An excessively high or low pressure may indicate a system problem and it may therefore be unadvisable to perform the flush and replace process. However, according to the teachings of the present invention, a transmission system exhibiting a low pressure (as indicated by a

pressure reading displayed on the pressure gauge 32) can be successfully flushed as the machine 10 does not rely on the transmission system fluid pressure to perform the fluid exchange, as described below.

[0032] If the system appears to be operating properly within an expected pressure range, the operator may add a flush chemical (i.e., a dispersive detergent) through the vehicle's transmission dipstick tube. The operator fills a new fluid tank 24 with a volume of transmission fluid equal to the capacity of the vehicle's transmission system. The vehicle is operated for about five to ten minutes to circulate the flush chemical and allow the transmission fluid temperature to increase to a nominal operating temperature, i.e., about 200° F. As is known in the art, the use of a flush chemical is not required, but may be beneficial to remove harmful deposits from the transmission system components.

[0033] As the hot used fluid flows through the heat coil 30 (formed from copper tubing in one embodiment), heat is transferred to the "cold" new fluid in the new fluid tank 24, thus warming the new fluid and cooling the used fluid. Hot used fluid can shorten the useful life of machine components as the hot fluid circulates through the machine 10; cooling the used fluid reduces the likelihood of this potential problem. Also, as the temperature of the new fluid increases toward the temperature of the used fluid the viscosity of the new fluid approaches the viscosity of the used fluid. That is, the viscosity of the new fluid (which can be especially high in cold weather) is reduced as its temperature rises. As the viscosity of the new fluid approaches the viscosity of the old fluid, the machine 10 provides an increasingly more accurate one-to-one volume ratio fluid exchange.

[0034] Further, as is known, the introduction of cold fluid into an operating transmission system is sensed by temperature sensors and thermostats that can trigger the closing and isolation of one or more fluid flow paths. The used fluid can become trapped within these closed paths, reducing the volume of fluid exchanged during the process and retaining some used fluid in the vehicle. By heating the used fluid as taught by the present invention, the likelihood of creating the trapped flow paths can be reduced since the heated new fluid is less likely to activate the temperature sensors and thermostats.

[0035] To perform the fluid exchange, the operator applies power to the machine 10, for example by turning the main power switch to an ON position (not shown in Figure 1). The application of power energizes the solenoid 36, redirecting the flow through the

dashed line energized path of the solenoid 36 to a chamber 44 where a float switch 50 senses the fluid and in response supplies power to pumps 60 and 62. Preferably, contacts within the float switch 50 are normally open, switching to a closed position in response to the rising fluid level in the chamber 44.

[0036] As the used fluid enters the chamber 44, the pump 60 empties the used fluid into a waste fluid tank 63. The pump 62 pulls new fluid from the new fluid tank 24 into a chamber 66. In one embodiment the pump 60 empties the chamber 44 at the same rate as the pump 62 fills the chamber 66.

[0037] When a float switch 54 senses fluid in the chamber 66, power is supplied to the pump 64. New fluid is thus withdrawn from the chamber 66 by the pump 64, supplying that fluid back to the vehicle through the fluid line 42, the check valve 41, a tee junction 70, the fluid line 38, the tee junction 40 and the valve 18 or the valve 20, depending on whether the valves 18 and 20 are in the A or the B position. Recall that the solenoid 32 is now in the energized position and thus fluid passing through the tee junction 70 cannot flow through the solenoid 36.

[0038] As the process continues, the pumps 60 and 62 continue to exchange fluid simultaneously to-and-from the chambers 44 and 66 at about a one-to-one rate. The pump 60 withdraws used fluid from the chamber 44 while the pump 62 fills the chamber 66 with new fluid. The pump 64 continues to independently fill the vehicle with fluid received from the pump 62 via the chamber 66. This process ensures that the volume of used fluid withdrawn from the vehicle is replaced by the same volume of new fluid, since the flow of used fluid from the vehicle controls the flow of new fluid to the vehicle. Use of the pump 64 to supply new fluid to the transmission system avoids the prior art difficulties associated with using the transmission system pump to power the refill process. Further, the pumps 60 and 62 operating in conjunction with the chambers 44 and 66, ensure about a one-to-one volume replacement of new fluid for used fluid.

[0039] During the fluid exchange process the withdrawal of used fluid from the vehicle may not be continuous nor always at a constant flow rate. Thus the pumps 60 and 62 cycle on and off under control of the position of the float switch 50 in response to the used fluid level in the chamber 44. When the fluid in the new fluid tank 24 nears a bottom surface 72 a float switch 74 is activated, disconnecting power from the solenoid 36 and returning the solenoid 36 to the normally opened state. The fluid flow path thus returns to the closed loop configuration in which the fluid flows from the vehicle

through one of the valves 18 and 20, through the fluid flow indicator 22, the heat coil 30, the pressure gauge 32, the solenoid 36, the tee junction 70, the fluid line 38 and the tee junction 40. The float switch 74 also activates an indicator on a machine operator's console (not shown in Figure 1) to indicate completion of the fluid exchange process. The operator de-energizes the machine at the completion of the process by positioning a main shut off switch (not shown) in an off position, effectively removing power from the machine components.

[0040] The new fluid volume in the new fluid tank 24, which was filled to the vehicle's fluid capacity prior to beginning the exchange process, meters the flow of new fluid into the vehicle to achieve the volume controlled replacement taught by the present invention. Use of the pump 64 to infuse new fluid into the vehicle provides a faster fluid exchange than available with prior art machines, reducing fluid intermixing and thus ensuring exchange of a greater percentage of the used transmission fluid for new transmission fluid.

[0041] During the fluid exchange process if the used fluid reaches a predetermined upper limit in the chamber 44, the rising fluid level is sensed by a float switch 52, which in turn de-energizes the solenoid 36 and the pumps 60 and 62. The machine 10 then returns to the closed loop mode where the transmission fluid pump forces fluid through the closed loop circuit of the machine 10. This feature reduces the possibility of overflowing the chamber 44 and running a vehicle's transmission system dry by continuing to withdraw fluid from the vehicle.

[0042] If at any time during the fluid exchange process external power is lost to the machine 10, the solenoid 36 and the pumps 60 and 62 are de-energized and the machine 10 returns to the closed loop circuit configuration.

[0043] In one embodiment, after the fluid replacement service has been completed, the machine 10 allows the operator to either lower or top-off the vehicle's transmission fluid level. Lowering the level is accomplished by operating the machine 10 in the closed loop mode and opening a valve/spigot 79 to withdraw fluid from the vehicle. The vehicle's transmission system pumps fluid from the vehicle out the opened valve/spigot 79. Since the machine 10 operates on a volume replacement principle, if the vehicle transmission system was in an over-filled condition prior to the fluid exchange process, the system will be overfilled at the conclusion of the replacement process. Thus it may be necessary to lower the fluid level through the valve/spigot 79 as described. Also, the

flush chemical introduced prior to initiating the fluid replacement process and any chemicals or fluids added to the system after finishing the refill process can create an over-filled condition.

[0044] If the volume of used fluid in the vehicle was low prior to beginning the refill process the volume of new fluid in the vehicle will also be low, as the machine 10 provides an approximately one-to-one fluid volume replacement. The operator can detect a low fluid volume by checking the dipstick level after completing the flush and refill process. To fill the transmission system to the correct volume, the pump 62 is manually activated by an override switch on the operator's counsel (not shown in Figure 1) to pump new fluid from the new fluid tank 24 into the vehicle. Typically, about a quart of new fluid will remain in the new fluid tank 24 after the operator de-energizes the machine 10 as described above. Operator activation of the override switch overrides the float switch 74 and energizes the pump 62 to fill the chamber 66 with new fluid. The float switch 54 in the chamber 66 energizes the pump 64 for pumping new fluid into the vehicle. A check of the fluid level with the dipstick will reveal when sufficient additional fluid has been added.

[0045] The valve/spigot 79 can also be used to extract samples of new or used fluid from the vehicle for inspection by the vehicle owner or the machine operator. The used fluid is removed via the valve/spigot 79 while the machine 10 is in closed loop operation (that is, wherein the solenoid 36 is in the normally opened position) before new fluid has been pumped into the vehicle. A new fluid sample is removed via the valve/spigot 79 after the refill process has been completed by operating the machine 10 in the closed loop position and opening the valve/spigot 79.

[0046] The service operation of dropping the transmission pan and replacing the transmission fluid filter can also benefit from use of the machine 10. This operation typically results in fluid spillage when the pan is removed from the transmission housing. To avoid the spillage, after the transmission system is filled with new fluid, the machine 10 can be run in the closed loop mode to withdraw new fluid through the valve/spigot 79 (the new fluid is retained in a container) until air bubbles are visible in the flow indicator 23. The air bubbles indicate that the pan is empty because the vehicle transmission pump draws fluid from the pan sump. The pan is dropped without fluid spillage, the filter is replaced, the pan is attached to the transmission housing and the

retained new fluid is poured back into the transmission through the dip stick tube or by using the machine top off process as described above.

[0047] The new fluid tank 24 can be drained by operating a switch (not shown) to energize the pump 62. New fluid remaining in the new fluid tank 24 is pumped into the chamber 66, the float switch 54 activates the pump 64 to pump the new fluid through the valve/spigot 79 where it can be captured and retained for later use. Since different fluids may be recommended for different vehicles, this feature is especially beneficial when different vehicles are serviced from the same machine 10 or anytime the operator desires to completely empty the tank and switch to an alternative transmission fluid.

[0048] In another embodiment of the machine 10, the pump 64 and the chamber 66 are not present. In such an embodiment the pump 60 pumps used fluid into the waste fluid tank 67 as described above. New fluid is pumped to the vehicle by the pump 62 through the fluid line 42 along the same fluid path as described in the embodiment above. However, it was recognized by the inventors that if an obstruction is present in the transmission fluid cooling system, the pump 62 will encounter some back pressure that reduces the rate at which new fluid is pumped into the vehicle, while the pump 60 encounters no restriction (open flow) as it pumps used fluid to the waste fluid tank 67. This situation may cause an unbalanced exchange rate of new fluid for old fluid, and the volume of new fluid pumped into the vehicle may therefore be below the recommended fluid capacity. An embodiment comprising the chamber 66 and the pump 64 is intended to overcome this disadvantage.

[0049] In lieu of using the two valves 18 and 20 as described above, in another embodiment the machine 10 comprises a four-way valve, such as a four-way valve 80 illustrated in Figure 2. A position of a handle 81 of the four-way valve 80 provides four different flow paths therethrough. When the handle 81 is in a position C, ports 83 and 84 (one of which provides fluid to the vehicle and the other of which receives fluid from the vehicle) supply fluid flow to ports 82 and 85, respectively. When the handle 81 is in a position D the ports 83 and 84 divert fluid into the opposite ports, i.e., the port 83 provides fluid to the port 85 and the port 84 provides fluid to the port 82, respectively. Thus the single four-way valve 80 operates as a functional replacement for the two two-way valves 18 and 20.

[0050] In another embodiment of the present invention, a bladder tank, or a functional equivalent thereto, is inserted into the fluid path between the pump 64 and the

tee junction 70. The bladder tank operates as a dampener to accept pressure from the pump 64 when a clog is present in the vehicle's transmission system. The bladder relives the pressure over a time interval dependent on the extent to which the obstruction causes a low flow rate from the pump 64.

[0051] In another embodiment the heat coil 30 is replaced by a fin-type heat exchanger, for example a radiator-like coil, comprising a plurality of sinuous fluid path segments and cooling fins extending outwardly therefrom to accelerate the heat transfer from the hot used fluid to the new cold fluid.

[0052] In the embodiments described above the various float switches were described as closing or opening to operate the various pumps of the machine 10. In an alternative embodiment, closure of the float switch contacts instead causes power to be supplied to a coil of a relay (not shown in Figure 1). The energized coil closes associated relay contacts through which machine power is supplied to the pump or pumps associated with the operative float switch. Opening of the float switch contacts causes de-energization of the relay coil and opening of the associated relay contacts.

[0053] In yet another embodiment, a second float switch (not shown in Figure 1) is included in the chamber 66 for controlling the pump 62. The second float switch shuts down the pump 62 when the fluid level in the chamber 66 reaches a high fluid limit. Use of the second float switch in the chamber 64 avoids an overflow situation where the chamber 66 fills with new fluid faster than the pump 64 can withdraw the fluid and pump the fluid into the vehicle. Such an overflow of the chamber 66 can be caused, for example, if the pump 64 becomes inoperative or if the vehicle transmission system is obstructed and preventing the pump 64 from pumping the new fluid into the system at the desired rate.

[0054] Generally, the machine 10 operates in one of the following modes: closed loop circulation (wherein the vehicle transmission system pump pumps the fluid through a closed loop in the machine 10 without replacing old fluid with new fluid), flush, raise fluid level/empty new fluid tank and lower fluid level.

[0055] The machine operator selects an operational mode by appropriately positioning one or more switches of the machine 10 (in a preferred embodiment the switches are located on the operator's console as described below). Operation of a first switch allows the machine 10 to operate in the raise fluid level/empty tank mode. In this mode the pump 62 and the solenoid 36 are energized; the float switch 54 and the pump 64 are

enabled. That is, the float switch 54 is operative to energize the pump 64 in response to the fluid level in the chamber 66. Further, in this mode the pump 60 and the float switch 74 are disabled, i.e., the pump 60 cannot be energized irrespective of the position of the float switch 74, which in turn is responsive to the fluid level in the new fluid tank 24. The vehicle fluid level is raised as the pump 62 supplies new fluid from the new fluid tank 24 to the chamber 66. The fluid level activates the float switch 54, energizing the pump 64 to pump fluid into the vehicle. In this mode the solenoid is in the closed state indicated by the dashed line fluid flow path.

[0056] To empty the new fluid tank 24 in this mode of operation, the valve/spigot 79 is opened while the pump 64 is pumping new fluid. The new fluid is diverted through the valve/spigot 79 before reaching the vehicle. .

[0057] In a second embodiment a second switch (also preferably located on the operator's console) can be used to lower the vehicle's fluid level by supplying power to the solenoid 36, disabling the pump 62 and enabling the float switch 50 to control the pump 60. With the solenoid energized, fluid is withdrawn from the vehicle into the chamber 44, activating the float switch 50 and turning on the pump 60. The operator de-energizes the solenoid 36 to return operation to the closed loop circulation mode when the vehicle's fluid level has fallen to the correct level.

[0058] A third switch (preferably located on the operator's console) controls the machine 10 to operate in the flush mode, during which the solenoid 36 is energized and the various float switches and pumps in Figure 1 are enabled, such that in response to the chamber fluid levels the associated float switch energizes the appropriate pump.

[0059] Those skilled in the art recognize that the functions of the individual console switches can be combined such that a multi-position switch, under operator control, can selectively cause the machine 10 to operate in the preferred mode.

[0060] Although described herein with reference to the exchange of transmission fluid in an automotive vehicle, those skilled in the art recognize that the teachings of the present invention can also be applied to the exchange of other fluids from a vehicle and further to the exchange of fluids for other machines. Further, although the machine 10 and the inventive features thereof have been described with reference to various pumps, those skilled in the art recognize that other devices capable of causing fluid flow can be used in place of conventional pumps, and thus the pumps described herein are intended to encompass such other devices.

[0061] Figure 3 illustrates the machine 10 electrically connected to a vehicle 100 via battery cables 102 and fluidly connected to a transmission system of the vehicle 100 by the fluid lines 13 and 15. A console 106 of the machine 10 includes the various manually operated switches and indicators described above.

[0062] A flush and fill process employing the machine 10 begins when the operator fills the new fluid tank 24. Typically about two to three quarts of fluid are required fill the various machine fluid flow paths and the bottom volume of the new fluid tank 24, that is, the volume below the float switch 74. The operator continues to fill the new fluid tank 24 until a sight tube 120 on the tank 24 (see Figure 1) indicates a tank volume equal to the vehicle transmission fluid capacity. The tank 24 thus contains the correct amount of fluid to perform the one-to-one fluid volume exchange.

[0063] For example, at the start of a typical service on a twelve-quart capacity vehicle, a technician may add fourteen quarts of transmission fluid to the machine 10, bringing the sight level up to the twelve-quart level, with the additional two quarts refilling the bottom volume of the new fluid tank 24 and any empty fluid flow paths. During the one-to-one exchange process, twelve quarts of fluid are pumped from the vehicle, and twelve quarts of fluid are pumped into the waste fluid tank 67.

[0064] If the vehicle fluid was slightly low when the service started, it will also be slightly low at the end of the service. The technician utilizes the top-off feature described above to pump a partial amount of the extra fluid remaining in the new fluid tank 24, back into the vehicle, thus raising the fluid level in the vehicle to the proper level.

[0065] By way of illustration, if the technician filled the new fluid tank 24 with twenty-four quarts of fluid, and then serviced a twelve-quart vehicle, the vehicle will not be twelve quarts overfilled. Since the operation according to the present invention executes a one-to-one fluid exchange, the vehicle's fluid level remains the same (twelve quarts). However, twelve wasted quarts of fluid will have been passed through the vehicle, and back into the waste fluid tank 67.

[0066] While the invention has been described with reference to preferred embodiments, it will be understood by those skilled in the art that various changes may be made and equivalent elements may be substituted for elements thereof without departing from the scope of the present invention. The scope of the present invention further includes any combination of the elements from the various embodiments set

forth herein. In addition, modifications may be made to adapt a particular situation to the teachings of the present invention without departing from its essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.